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MULTILINGUAL EDUCATION IN LIFE SCIENCES: TEACHERS' AND LEARNERS' BELIEFS ABOUT CODE-SWITCHING

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Abstract. *In South Africa, where multilingualism is prevalent, code-switching—a practice of alternating between languages—plays a significant role in shaping classroom dynamics and learning outcomes. This study explores the beliefs of both teachers and learners regarding code-switching in Life Sciences classrooms. Utilizing quantitative methods, the research is grounded in the Cognitive Academic Language Proficiency (CALP) framework which emphasizes the pivotal role of language in the learning process. Data were collected from 100 learners and 44 secondary school teachers across multilingual areas in Sedibeng West, Gauteng Province in South Africa, using questionnaires. The findings reveal that teachers view code-switching as an effective strategy for clarifying complex scientific concepts and addressing language barriers, despite concerns about its potential impact on language proficiency and dependency. Learners, on the other hand, value code-switching for its role in making learning material more accessible and understandable. This study highlights the nuanced role of code-switching in enhancing educational outcomes in multilingual settings and suggests its potential benefits and challenges in the context of Life Sciences education.*

Keywords: *cognitive academic language proficiency, code-switching, learner beliefs, multilingual education, teacher beliefs*

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Introduction

South Africa's educational landscape is characterized by its rich linguistic diversity, with multiple languages spoken within the same classroom. This multilingual environment presents both challenges and opportunities for effective teaching and learning. In subjects such as Life Sciences (Biology), where specialized vocabulary and complex concepts are integral, code-switching—alternating between languages during instruction—has emerged as a prominent strategy to facilitate comprehension and engagement. Understanding the beliefs of both teachers and learners regarding code-switching is crucial for optimizing educational practices and supporting academic success in multilingual settings.

The seamless transition between two or more languages or dialects during a single discourse, known as code-switching, has emerged as a significant focus in educational research (Maluleke, 2019; Mujioono et al., 2013). This phenomenon is prevalent in multilingual contexts, where teachers and learners frequently code switch to enhance comprehension of scientific concepts in the classroom (Archila et al., 2018; Maluleke, 2019). Teachers often adjust their pedagogical strategies to accommodate the diverse linguistic backgrounds of their learners. The adaptability of code-switching not only fosters an inclusive learning environment but also improves clarity and accessibility (Corcoll, 2013; Maluleke, 2019). When employed strategically in Life Sciences classrooms, code-switching can enhance learners' understanding and boost classroom participation (Abdullah & Hussin, 2021; Corcoll, 2013).

A thorough examination of the beliefs held by both teachers and learners is essential to fully grasp the dynamics of code-switching in the classroom (Cahyani et al., 2016; Makgota, 2014). Teachers' views on language policies, teaching methods, and the perceived effects of code-switching on learners' understanding and academic performance often reflect their broader perspectives on language use (Mwangu & Sibanda, 2017; Songxaba et al., 2017). While some teachers may regard code-switching as a potential hindrance to academic rigor and language development, others may see it as a valuable communication and learning tool (Fatimah, 2016; Songxaba et al., 2017).

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These views are shaped by teachers' cultural backgrounds, training, and educational goals. Conversely, learners' attitudes towards code-switching are influenced by broader cultural perceptions of language proficiency and diversity (Ferreira, 2011; Makgota, 2014).

The exploration of teachers' and learners' beliefs about code-switching in Life Sciences classrooms is not merely an academic exercise; it is a crucial exploration of how language dynamics influence educational outcomes. By examining these beliefs, this study aims to illuminate the nuanced ways in which code-switching can be leveraged to bridge linguistic and conceptual gaps, thereby enhancing comprehension and engagement in Life Sciences. The insights garnered not only contribute to the existing body of knowledge but also inform pedagogical practices that are culturally responsive and linguistically inclusive. Ultimately, this research aspires to foster an educational environment where linguistic diversity is viewed as an asset, integral to the teaching and learning process in Life Sciences.

Research Problem

Various factors influence the effective teaching and learning of science. Language plays a central role in education as it facilitates reasoning and impacts learning outcomes (Omidire & Ayob, 2022). In the South African educational landscape, learners face challenges with the language of teaching and learning (LoLT), which is predominantly English from lower grades through to Grade 12 (Department of Basic Education [DBE], 1997). Code-switching (CS), defined by Kamwangamalu (2010) as "the intersectional alternating use of two or more languages or varieties of a language in the same speech situation" (p. 116), has become a significant strategy in this context. Bhatti et al., (2018) argued that both teachers and learners use CS within the classroom to interchange languages, thereby enhancing the retention of concepts and making learning more accessible, especially for those not proficient in LoLT.

Code-switching serves as a mediator between learners, learning content, and the teacher (Grobler, 2018). Songxaba et al. (2017) have described how teachers have intentionally used CS to enhance learners' educational experiences, particularly when comprehending complex concepts. In inquiry-based learning (IBL), CS can promote deeper thinking and facilitate discussions among learners from diverse language and cultural backgrounds. The proficiency in LoLT significantly affects the effectiveness of IBL, as learners proficient in LoLT are better equipped to engage in these activities. Despite international advocacy for strategies to address English proficiency challenges in science education, there is limited research on how CS can improve learners' performance in IBL and how teachers can effectively use CS to enhance Life Sciences instruction and knowledge acquisition in South Africa. Previous studies have primarily focused on overcoming obstacles in science education. Code-switching is increasingly recognized as a valuable pedagogical approach to support learners in this context.

Recent research on code-switching in classrooms highlights a range of perspectives from both teachers and learners. Some teachers view code-switching as an effective strategy to enhance communication and comprehension, especially for learners with limited proficiency in the language of instruction (Chikiwa & Schafer, 2016; Ferreira, 2011; Mwangu & Sibanda, 2017). They believe it makes complex scientific concepts more accessible. Conversely, other teachers express concerns that code-switching might negatively impact learners' academic performance and language development, potentially hindering their acquisition of essential language skills (Almelhi, 2020; Al-Qaysi, 2018). Understanding teachers' and learners' beliefs about code-switching in Life Sciences classrooms is pivotal for fostering effective teaching and learning environments in multilingual contexts. The research problem highlights the complex interplay between language, cognition, and pedagogy, underscoring the necessity of recognizing and valuing linguistic diversity as a pedagogical tool. By delving into the perceptions and practices surrounding code-switching, this research seeks to uncover how such linguistic strategies can be harnessed to support conceptual understanding and academic achievement.

Conceptual Framework

This study is grounded in the Cognitive Academic Language Proficiency (CALP) framework, which underscores the importance of language proficiency in academic contexts. CALP highlights that proficiency in academic language is essential for learners to grasp complex concepts and engage in higher-order thinking. Cognitive Academic Language Proficiency, a concept developed by Cummins (2001), refers to the advanced level of language skills required to understand and engage with academic content, particularly in complex subjects like science. CALP is distinct from Basic Interpersonal Communicative Skills (BICS), which involve everyday conversational language.

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CALP is essential for academic success because it involves the ability to use language for higher-order thinking, analysis, and understanding in an academic context.

In the study, CALP helps to identify the language proficiency required for learners to effectively grasp complex scientific concepts in Life Sciences. The study explores teachers' and learners' beliefs about how code-switching might support or hinder the development of CALP by providing additional linguistic resources that aid comprehension and engagement with academic content. Teachers' beliefs about code-switching are influenced by their understanding of CALP. Teachers who recognize the importance of CALP may view code-switching as a useful strategy to bridge gaps between learners' everyday language and the academic language needed for understanding Life Sciences concepts (Zainil & Arsyad, 2021). This perspective aligns with the idea that code-switching can facilitate the development of CALP by making challenging content more accessible to learners (Maluleke, 2019).

In summary, CALP provides a framework for understanding how code-switching impacts the development of academic language skills necessary for success in Life Sciences classrooms. It helps to evaluate the effectiveness of code-switching in supporting learners' comprehension and engagement with complex scientific concepts and informs teachers' approaches to language use in the classrooms.

Research Aim and Research Questions

The purpose of the study was to explore both teachers' and learners' beliefs regarding the use of code-switching in the context of Life Sciences education. The study sought to answer the research questions: 1. What are the beliefs of teachers and learners regarding the use of code-switching in Life Sciences classrooms? 2. How do these beliefs influence the effectiveness of code-switching as a pedagogical tool for teaching and learning?

Research Methodology

General Background

This study utilized a quantitative research design to explore teachers' and learners' beliefs about the use of code-switching (CS) in Life Sciences classrooms. Quantitative research is well-suited for obtaining a specific, comprehensive understanding of a phenomenon through numerical data and statistical analysis (Creswell & Clark, 2017). In this study, conducted over a period of six months under classroom-based conditions, questionnaires have been employed as the primary data collection method to capture detailed perspectives on the impact of code-switching on teaching and learning in Life Sciences.

Participants

The research targeted Grade 10 Life Sciences teachers and learners from four township schools in Sedibeng West, Gauteng Province in South Africa. It focused on a diverse sample that included both male and female participants, predominantly from low- to middle-income households, with varied linguistic backgrounds commonly reflective of the multilingual communities in the region. A purposive sampling method was used to select participants who could provide relevant and comprehensive insights into the use of code-switching in this context. Informed by Creswell (2015), purposive sampling was employed to ensure that the participants had direct experience with code-switching in classrooms, which is particularly prevalent in the diverse linguistic environment of township schools. A total of 44 Life Sciences teachers and 100 Grade 10 learners took part in the study.

Learner Demographic Profiles

Table 1 provides a snapshot of the demographic profile of learners who participated in the study, detailing their gender, racial background, and home language. This biographical information is crucial for contextualizing the study's findings and understanding how demographic factors might influence learners' experiences and perceptions. The gender distribution among the learners shows a higher representation of males (59%) compared to females (41%). This imbalance is not unusual in certain educational contexts but is significant in analyzing how gender might impact learners' beliefs and experiences regarding code-switching in Life Sciences classrooms. It may be worthwhile to explore whether gender-related factors influence attitudes towards code-switching or classroom participation.

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The racial composition of the learners reflects a diverse student body with the majority identifying as Black (59%). This is followed by Coloured (25%), White (11%), and Indian (5%) learners. The substantial representation of Black and Coloured learners suggests that the findings may predominantly reflect the perspectives and experiences of these groups. Understanding the racial diversity is essential for interpreting how code-switching is perceived and utilized across different racial contexts. For instance, the prominence of Black learners might indicate a particular linguistic and cultural context that influences their interaction with code-switching practices. The home language distribution among learners reveals a rich linguistic diversity. Most learners speak IsiZulu (21%) or Southern Sotho (17%) at home, which highlights the multilingual environment in which the learners operate. Other notable home languages include IsiXhosa (14%) and English (27%), with Afrikaans (9%), Setswana (9%), and Northern Sotho (3%) representing smaller proportions. This linguistic diversity suggests that learners are accustomed to navigating multiple languages, which could influence their experiences with code-switching in the classroom. The predominance of English as a home language, despite its lower percentage (27%), indicates its significant role in learners' academic and social interactions. The presence of several indigenous languages further illustrates the complexity of linguistic dynamics in the classroom and underscores the need for inclusive pedagogical approaches that accommodate and leverage this linguistic richness.

The demographic details presented in Table 1 offer valuable insights into the learner population and set the stage for a deeper analysis of how these factors may influence their views on code-switching. The gender imbalance could lead to variations in how code-switching is perceived or employed by male and female learners. Exploring these differences might uncover gender-specific preferences or challenges related to code-switching. The predominance of Black learners and the diversity of home languages suggest that code-switching practices are likely shaped by a complex interplay of racial and linguistic factors. It is essential to consider how these factors influence learners' experiences and expectations regarding code-switching in Life Sciences instruction. Given the variety of home languages, it is important to assess how well code-switching practices align with learners' linguistic backgrounds and whether they support effective learning outcomes.

In summary, Table 1 provides a foundational understanding of the learner demographics, which is critical for interpreting the study's findings on code-switching. This biographical context helps in analyzing how gender, race, and language may affect learners' attitudes towards code-switching and informs recommendations for more effective and inclusive teaching practices.

Table 1
Learners' Biographical Details

Item	Category	*N*	%
Gender	Male	59	59.0
	Female	41	41.0
Racial group	Black	59	59.0
	Colored	25	25.0
	Indian	5	5.0
	White	11	11.0
Language	Afrikaans	9	9.0
	English	27	27.0
	Tswana	9	9.0
	Xhosa	14	14.0
	Zulu	21	21.0
	Southern Sotho	17	17.0
	Northern Sotho	3	3.0

Teachers' Demographic Profiles

Table 2 offers a comprehensive overview of the demographic and professional background of the teachers involved in the study. The data provides insights into their gender, racial background, home languages, qualifica-

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tions, and teaching experience, which are essential for contextualizing their perspectives and practices regarding code-switching and inquiry-based learning in Life Sciences. The gender distribution among the teachers shows a majority of male teachers (52.3%) compared to female teachers (43.2%). A small percentage (4.5%) preferred not to disclose their gender. This distribution indicates a relatively balanced gender representation, with a slightly higher proportion of males. This gender balance is relevant for understanding potential gender-related differences in teaching styles, perspectives on code-switching, and engagement with inquiry-based learning methods.

The racial composition of the teachers reveals a predominant representation of Black teachers (65.9%), followed by Coloured (18.2%), White (15.9%), and Afrikaans (6.8%). This diverse racial background reflects the multi-ethnic nature of the teaching staff and provides insight into the cultural and contextual factors influencing their approaches to teaching Life Sciences. The predominance of Black teachers might also impact the classroom dynamics and the ways in which code-switching, and inquiry-based learning are implemented and perceived. The data on home languages indicates a rich linguistic diversity among the teachers. English (22.7%) and IsiZulu (20.5%) are the most spoken home languages, followed by Setswana (18.2%), IsiXhosa (13.6%), Southern Sotho (13.6%), and Northern Sotho (4.5%). This linguistic diversity highlights the various language backgrounds of the teachers, which could influence their perspectives on code-switching and their ability to support multilingual classroom environments effectively. Understanding the home languages of teachers can also inform how they integrate their linguistic skills into their teaching practices.

In terms of educational qualifications, most teachers held undergraduate degrees (54.5%), with a smaller proportion having diplomas (18.2%) or postgraduate qualifications (27.3%). This distribution reflects a generally well-qualified teaching staff, with a majority possessing undergraduate degrees. The qualifications of the teachers are crucial for understanding their depth of knowledge and expertise in Life Sciences and their readiness to implement advanced pedagogical strategies. Most teachers have been teaching Life Sciences for eight years or less (75.0%), while 25.0% have more than eight years of experience. This indicates a predominance of relatively newer teachers in the field, which may affect their familiarity with established teaching practices and their openness to innovative approaches such as code-switching and inquiry-based learning. The experience level of teachers is significant in evaluating their perspectives and practices, as more experienced teachers might have different insights compared to their less experienced counterparts.

In summary, Table 2 provides a detailed profile of the teachers involved in the study, highlighting their gender, racial background, home languages, qualifications, and teaching experience. This demographic and professional information is essential for interpreting the teachers' perspectives on code-switching and inquiry-based learning. The diversity in racial backgrounds and home languages, combined with varying levels of qualifications and teaching experience, offers a rich context for understanding how these factors might influence teachers' approaches to and beliefs about pedagogical practices in Life Sciences classrooms.

Table 2
Teachers' Biographical Details

Item	Category	*N*	%
Gender	Male	23	52.3
	Female	19	43.2
	Prefer not to say	2	4.5
Racial group	Black	29	65.9
	Colored	8	18.2
	White	7	15.9
	Afrikaans	3	6.8
Language	English	10	22.7
	Tswana	8	18.2
	Xhosa	6	13.6
	Zulu	9	20.5
	Southern Sotho	6	13.6
	Northern Sotho	2	4.5

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Item	Category	*N*	%
Qualification	Diploma	8	18.2
	Undergraduate	24	54.5
	Postgraduate	12	27.3
Teaching experience	Eight years and below	33	75.0
	More than eight years	11	25.0

Instrument and Procedures

Data were collected using two versions of a structured questionnaire, one for teachers and one for learners, to systematically capture insights into beliefs about code-switching and its impact on inquiry-based learning in Life Sciences classrooms. The use of questionnaires was justified by the need for a standardized method that could efficiently gather diverse perspectives on code-switching's perceived effectiveness, benefits, and drawbacks across a large sample. Each questionnaire consisted of items rated on a 5-point Likert scale, providing a structured framework to assess respondents' attitudes and beliefs in a quantifiable manner. Administering the questionnaires remotely via Google Forms minimized classroom disruptions and allowed for convenient data collection without interfering with ongoing teaching and learning processes. This remote approach also facilitated broader participation, enabling responses from a geographically dispersed sample and thereby enhancing the generalizability of findings.

Data Analysis

Descriptive statistics were employed to summarize and present the data, including percentages, means, and standard deviations of participants' responses. Descriptive statistics were computed as they are useful for simplifying large data sets and providing a clear summary of the responses (George & Mallery, 2016). Inferential statistics were also used to explore differences within the data. Independent t-tests and correlation analyses were conducted to examine the effectiveness of code-switching on learners' comprehension and engagement, and to identify any significant differences between the beliefs of teachers and learners.

Reliability and Validity

In the study, the concepts of reliability and validity were fundamental to ensuring the integrity and credibility of the research findings. To establish a strong foundation for these concepts, various strategies were employed throughout the research process. To enhance reliability, the research instruments underwent thorough pilot testing with a small group of participants who resembled the target population. This pilot phase allowed for the identification of any ambiguities or difficulties within the questions, leading to necessary adjustments that enhanced clarity and coherence. Additionally, internal consistency was assessed using statistical measures such as Cronbach's alpha. A Cronbach's alpha value of .70 or higher was considered indicative of acceptable reliability, ensuring that the items within the questionnaires consistently measured the same construct. The validity of the study was addressed through a multi-faceted approach. Content validity was a primary focus, achieved by developing research instruments based on a comprehensive review of relevant literature and existing frameworks related to code-switching and multilingual education. Expert reviews were solicited to ensure that the instruments effectively captured the constructs being studied, confirming that the items were representative of the beliefs of both teachers and learners regarding code-switching. Construct validity was further supported through exploratory factor analysis for the questionnaires, assessing whether items grouped together as anticipated and aligned with the theoretical constructs at play. By grounding the study in relevant theoretical frameworks associated with multilingual education and code-switching, the research established a solid basis for measuring the constructs in question. External validity was also prioritized by including a diverse sample of Grade 10 Life Sciences teachers and learners from various township schools in Sedibeng West, Gauteng Province in South Africa. This diversity enhanced the generalizability of the findings to similar educational contexts within multilingual settings. Where applicable, the findings were compared with those of previous studies on code-switching and multilingual education to identify

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consistent patterns, further bolstering external validity. Lastly, face validity was evaluated through feedback from key stakeholders, including teacher educators and language experts, who reviewed the research instruments to ascertain their apparent ability to measure the intended constructs effectively.

By systematically addressing these aspects of reliability and validity, the study aimed to enhance the credibility of its findings. The insights garnered contributed significantly to understanding teachers' and learners' beliefs about code-switching in Life Sciences education, ensuring that the research was conducted with the highest standards of integrity and rigor.

Ethical Considerations

For the study, several ethical considerations were crucial to ensure the protection of participants' rights and the integrity of the research. First, informed consent was a priority. All participants, including both teachers and learners, were fully informed about the purpose, objectives, and procedures of the study. Given that some participants were minors, the consent of their guardians was also sought. Consent forms were designed to be easily understood by participants and were available in multiple languages to accommodate the linguistic diversity of the sample. This process ensured that participants were aware of their role in the study and any potential risks or benefits involved. Confidentiality and anonymity were strictly maintained throughout the research process. To protect participants' identities, pseudonyms or participant codes were used in place of real names in all documentation and reports. Any data collected was securely stored, accessible only to the research team, and destroyed after the completion of the study to further safeguard participants' privacy.

Participation in the study was entirely voluntary, and participants were made aware of their right to withdraw from the study at any time, without any repercussions. No coercion was used, and participants were assured that their decision to participate or withdraw would not affect their educational experience or relationships with teachers or peers. A key consideration in this study was cultural and linguistic sensitivity. Since the research focused on code-switching in multilingual Life Sciences classrooms, it was essential to respect the linguistic practices of the participants. Data collection tools, including questionnaires and interviews, were provided in languages that participants were comfortable with. Additionally, the research was conducted in a way that acknowledged and respected the cultural diversity of the communities involved, ensuring that participants felt valued and respected throughout the process.

In conducting this study, minimizing harm was of utmost importance. Discussions around language practices, particularly code-switching, could be a sensitive issue for some individuals, as it often touched on identity, language hierarchies, and perceived competence. To minimize any psychological or emotional discomfort, the research team adopted a non-judgmental and supportive approach, encouraging participants to express their beliefs and experiences openly without fear of criticism. Before beginning data collection, the study sought and received ethical approval from an institutional research ethics committee. This ensured that all ethical guidelines were adhered to, including the protection of participants' rights and welfare. Finally, after the study was completed, participants received a debriefing that provided insights into the findings and the implications of the research. Any concerns or questions participants had were addressed, ensuring that they felt fully informed about the outcomes of the study. By addressing these ethical considerations, the study upheld the highest standards of research ethics, ensuring that it was conducted in a manner that respected participants' rights, cultural backgrounds, and well-being.

Research Results

Learners' Beliefs about Code-switching in Enhancing Inquiry-based Learning

Table 3 presents learners' perceptions of how code-switching influences inquiry-based learning (IBL) in Life Sciences. The responses reflect varying degrees of agreement with statements regarding the role of code-switching in supporting and enhancing their learning experiences. The data is analyzed in terms of the mean scores and standard deviations to provide insights into learners' overall beliefs and attitudes. Learners generally perceive code-switching as beneficial for inquiry-based learning, with mean scores ranging from 2.89 to 3.38 on a 4-point scale. The mean score of 3.18 (SD = 1.274) for the statement "Code switching plays a vital role in the IBL of Life Sciences content" indicates a positive overall view, with 52% of learners agreeing or strongly agreeing that code-switching is crucial for IBL. This suggests a recognition of code-switching as an essential tool for engaging with Life Sciences content more effectively.

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The statement "Code switching enables me to construct knowledge with little guidance from my teacher" received a mean score of 3.24 (*SD* = 1.129). This reflects a somewhat positive belief among learners that code-switching aids in independent knowledge construction. While 42% of learners agreed or strongly agreed, a significant proportion (34%) remained neutral. This neutrality might suggest variability in how learners experience the impact of code-switching on their independence in learning. For the statement "Code switching makes me engage more in IBL in Life Sciences content," the mean score of 2.95 (*SD* = 1.058) indicates a more moderate view. With 33% of learners agreeing or strongly agreeing and 36% disagreeing or strongly disagreeing, the responses suggest that while some learners find code-switching enhancing engagement, others do not perceive a strong impact. This variability could be influenced by individual preferences or the specific contexts in which code-switching is used.

The mean score of 3.22 (*SD* = 1.097) for "Code switching develops my ability to ask questions" suggests a generally positive view, with 39% of learners agreeing or strongly agreeing. This indicates that learners believe code-switching supports the development of inquiry skills, although 33% were neutral, highlighting some uncertainty about its effectiveness in fostering questioning abilities. The statement "Using code-switching in IBL enhances learners' ability to make connections between Life Sciences content and everyday life" has a mean score of 2.89 (*SD* = 1.024). This lower score, with 28% agreeing or strongly agreeing and 38% disagreeing or strongly disagreeing, suggests that while some learners see value in connecting academic content with everyday experiences through code-switching, others do not find it significantly impactful. This discrepancy may reflect differences in how learners relate academic content to their personal lives. The highest mean score, 3.38 (*SD* = 1.013), is associated with the statement "The use of code switching in group activities enhances IBL." This indicates strong agreement among 49% of learners that code-switching positively impacts group-based inquiry learning. Similarly, a mean score of 3.27 (*SD* = 1.179) for "Using code-switching during discussions allows for the asking of important questions in IBL" further supports the notion that code-switching is viewed favorably in contexts that involve collaborative and discussion-based learning activities.

Overall, Table 3 indicates that learners generally hold a positive belief about the role of code-switching in enhancing inquiry-based learning, especially in group settings and discussions. However, there are varied perceptions regarding its effectiveness on independent knowledge construction, engagement with content, and making connections to everyday life. These mixed responses highlight the need for teachers to consider the diverse ways in which code-switching can be employed to support different aspects of inquiry-based learning and to tailor its use to the specific needs and preferences of learners.

Table 3
Learners' Beliefs about Code-switching in Enhancing Inquiry-based Learning

Item	Strongly Disagree/ Disagree (%)	Neutral (%)	Strongly Agree/ Agree (%)	*M*	*SD*
Code switching plays a vital role in the IBL of Life Sciences content.	34.0	14.0	52.0	3.18	1.27
Code switching enables me to construct knowledge with little guidance from my teacher.	24.0	34.0	42.0	3.24	1.13
Code switching makes me engage more in IBL in Life Sciences content.	36.0	31.0	33.0	2.95	1.06
Code switching develops my ability to ask questions.	28.0	33.0	39.0	3.22	1.10
Using code-switching in IBL enhances learners' ability to make connections between Life experiences content and everyday life.	38.0	34.0	28.0	2.89	1.02
The use of code switching in group activities enhances IBL.	19.0	32.0	49.0	3.38	1.01
Using code switching during discussions allows for the asking of important questions in IBL.	30.0	21.0	49.0	3.27	1.18
				3.16	1.11

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Learners' Beliefs about the Use of Inquiry-based Learning

Table 4 displays learners' perceptions of the effectiveness of Inquiry-Based Learning (IBL) in the classroom. This table captures their beliefs about how IBL influences their learning experience, focusing on various aspects such as meaning construction, engagement, and skill development. The data, analyzed through mean scores and standard deviations, reveals diverse views on IBL's effectiveness. The statement "Inquiry-based Learning allows me to construct meaning without the teacher's involvement" has a mean score of 2.75 (*SD* = 1.329). This relatively low score indicates that more than half of the learners (52%) disagree or strongly disagree with the idea that IBL enables them to independently construct meaning without teacher guidance. This suggests that learners may feel that teacher involvement remains crucial in their learning process, even within an IBL framework. The significant proportion of neutral responses (21%) further reflects uncertainty or variability in learners' experiences regarding the extent of teacher facilitation in IBL.

Learners view IBL as a tool that promotes deeper thinking, with a mean score of 3.14 (*SD* = 1.054). A notable 40% of learners agree or strongly agree that IBL encourages more profound cognitive engagement. This positive perception aligns with IBL's pedagogical goals of fostering critical thinking and analytical skills. However, the 33% of neutral responses suggest that not all learners perceive the same level of depth in their thinking because of IBL, indicating that its effectiveness in promoting deeper cognitive processes may vary among individuals. The mean score for "Inquiry-based learning keeps me engaged in the classroom" is 2.98 (*SD* = 1.119), reflecting a moderate view on the role of IBL in maintaining classroom engagement. With 36% of learners agreeing or strongly agreeing, and 34% disagreeing or strongly disagreeing, the responses indicate that while IBL can be engaging for some, its impact on engagement is not universally felt. This variability highlights the need for teachers to tailor IBL approaches to enhance engagement for a broader range of learners.

The statement "Inquiry-based learning reinforces what I am learning" has a mean score of 2.94 (*SD* = 1.213). With 37% of learners agreeing or strongly agreeing, compared to 43% who disagree or strongly disagree, the data suggests a mixed view on IBL's role in reinforcing learning. This indicates that while some learners find IBL beneficial for reinforcing their understanding, others may not perceive the same level of reinforcement, potentially due to differing experiences or instructional implementations. IBL's ability to "ignite curiosity" among learners is reflected in a mean score of 3.00 (*SD* = 1.054). The relatively balanced response, with 36% agreeing or strongly agreeing and 38% disagreeing or strongly disagreeing, suggests that while IBL is perceived to spark curiosity for some learners, it does not have a uniform effect across the board. This variability points to the need for IBL strategies that more consistently stimulate curiosity and enthusiasm.

The mean score for "Inquiry-based learning helps to develop problem-solving skills" is 2.98 (*SD* = 1.073). The even distribution of agreement and disagreement (34% each) reflects a moderate belief in IBL's effectiveness in enhancing problem-solving abilities. This suggests that while IBL may contribute to problem-solving skill development for some learners, others may not experience the same level of benefit. Finally, the statement "Inquiry-based learning increases cooperation in the classroom" has the highest mean score of 3.07 (*SD* = 1.437). With 40% of learners agreeing or strongly agreeing, this indicates a favorable view of IBL's impact on fostering collaborative learning environments. The lower percentage of disagreement (42%) compared to other statements suggests that IBL is particularly effective in promoting cooperative interactions among learners.

In summary, Table 4 reflects a nuanced perspective on the role of Inquiry-Based Learning in the classroom. While learners generally perceive IBL as beneficial in promoting deeper thinking, curiosity, and cooperation, there is variability in its effectiveness for engagement, meaning construction without teacher involvement, reinforcement of learning, and problem-solving skill development. These insights highlight the importance of adapting IBL strategies to better meet learners' diverse needs and ensure that its benefits are maximized across different aspects of the learning experience.

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Table 4
Learners' Beliefs about the Use of IBL

Item	Strongly Disagree/ Disagree (%)	Neutral (%)	Strongly Agree/ Agree (%)	*M*	*SD*
Inquiry-based Learning allows me to construct meaning without the teacher's involvement.	52.0	21.0	27.0	2.75	1.33
Inquiry-based Learning promotes deeper thinking.	27.0	33.0	40.0	3.14	1.05
Inquiry-based learning keeps me engaged in the classroom.	34.0	30.0	36.0	2.98	1.12
Inquiry-based learning reinforces what I am learning.	43.0	20.0	37.0	2.94	1.21
Inquiry-based learning ignites curiosity.	38.0	26.0	36.0	3.00	1.05
Inquiry-based learning helps to develop problem-solving skills.	32.0	34.0	34.0	2.98	1.07
Inquiry-based learning increases cooperation in the classroom.	42.0	18.0	40.0	3.07	1.44
				2.98	1.18

Teachers' Beliefs about Code-switching

Table 5 presents teachers' beliefs about the role and impact of code switching (CS) in Life Sciences education. The table includes responses to various items related to the effectiveness and implications of CS, as measured by mean scores and standard deviations. The findings offer a nuanced view of teachers' attitudes toward CS in the classroom. Most teachers hold positive beliefs about the benefits of code-switching (CS) in Life Sciences education. Specifically, 52.3% of teachers agree that CS helps learners in Life Sciences, with a mean score of 3.23. This indicates that many teachers see CS as a valuable tool for supporting learning in this subject area. Furthermore, a significant portion of teachers (65.9%) agree that CS is effective in explaining difficult concepts, as reflected by a high mean score of 3.66. This suggests that teachers frequently use CS to enhance their explanations of complex material, which likely aids in learner comprehension.

Similarly, 63.6% of teachers use CS to assess learners' understanding of Life Sciences, with a mean score of 3.66. This underscores the role of CS not only as a pedagogical aid but also as a formative assessment tool. Additionally, 56.8% of teachers view CS as a pedagogical approach that facilitates understanding of Life Sciences concepts, with a mean score of 3.57. This reinforces the idea that CS is seen as a supportive strategy for enhancing conceptual comprehension. There is a notable degree of neutrality and mixed opinions among teachers regarding the effectiveness of CS in specific contexts. For instance, while 45.5% of teachers believe that CS acts as a scaffold in learning Life Sciences, the mean score of 3.52 indicates that this view is not as strongly held as other positive beliefs. Similarly, 59.1% of teachers think that CS should be used as a last resort, reflecting a cautious approach to its application. The mean score of 3.59 supports the idea that while CS is valued, its use is considered a secondary strategy rather than a primary one.

Despite the generally positive outlook, there are concerns about the potential drawbacks of CS. The item "Code switching poses barriers for learners to develop scientific literacy" received a mean score of 2.55, with 54.5% of teachers disagreeing with this statement. This suggests that while some teachers may acknowledge potential issues with CS, the majority do not perceive it as a significant barrier to scientific literacy development. Additionally, 27.3% of teachers feel that CS hinders learners' comprehension in class, as indicated by a mean score of 2.68. This points to a concern that CS might negatively impact learners' understanding in certain contexts.

Overall, the data from Table 5 reveal a generally favorable attitude towards the use of code switching in Life Sciences classrooms, with teachers recognizing its benefits in explaining concepts, assessing understanding, and facilitating learning. However, there is also a cautious perspective, with some teachers preferring to use CS sparingly and expressing concerns about its potential drawbacks. The average mean score of 3.31, with a standard deviation of 1.220, reflects a balanced view where CS is appreciated as a supportive tool but is not without its challenges.

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Table 5
Teachers' Beliefs about Code-switching

Item	Strongly Disagree/ Disagree		Neutral		Strongly Agree/ Agree		*M*	*SD*
	N	%	*N*	%	*N*	%		
Code switching helps learners in Life Sciences.	13	29.5	8	18.2	23	52.3	3.23	1.33
Code switching poses barriers for learners to develop scientific literacy.	24	54.5	10	22.7	10	22.7	2.55	1.30
Code switching acts as a scaffold in learning Life Sciences.	8	18.2	16	36.4	20	45.5	3.52	1.07
Code switching should be last resort in teaching Life Sciences.	8	18.2	10	22.7	26	59.1	3.59	1.13
I use code switching to check learners' understanding of Life Sciences.	10	22.7	6	13.6	28	63.6	3.66	1.1
Code switching helps in explaining difficult concepts.	7	15.9	8	18.2	29	65.9	3.66	1.08
Code switching as a pedagogical approach that facilitates learner understanding of Life Sciences concepts.	10	22.7	9	20.5	25	56.8	3.57	1.32
Code switching hinders learners' comprehension in class.	19	43.2	13	29.5	12	27.3	2.68	1.44
							3.31	1.22

Teachers' Beliefs about the Use of Inquiry-based Learning

Table 6 offers insights into teachers' beliefs about inquiry-based learning (IBL) in Life Sciences classrooms. The table summarizes responses to various statements about IBL, reflecting both the teachers' understanding and their attitudes towards its implementation. The data are presented in terms of frequencies (*N*), percentages, means, and standard deviations (*SD*). The data reveal a generally positive attitude towards IBL among teachers. A substantial majority, 72.1%, express a desire to implement IBL in their Life Sciences classrooms, as indicated by a high mean score of 3.72. This enthusiasm suggests that many teachers see IBL as a valuable pedagogical approach and are motivated to incorporate it into their teaching practices.

Similarly, 69.8% of teachers seek more support in implementing IBL, as reflected by a mean score of 3.91. This indicates a recognition of the benefits of IBL and a desire for additional resources or training to effectively apply it in their classrooms. The strong agreement with this statement underscores the importance of providing adequate support to facilitate the successful integration of IBL into teaching practices. Most teachers, 55.8%, feel they understand the process of IBL, with a mean score of 3.53. This suggests a relatively solid grasp of IBL concepts among teachers, although there is room for improvement. Additionally, 74.4% of teachers agree that IBL allows learners to ask important questions and engage in research beyond textbook learning, which is a core component of IBL. The high mean score of 3.81 supports the notion that teachers value the opportunity for learners to explore and inquire independently.

Despite the overall positive outlook, there are notable concerns regarding the implementation of IBL. A significant portion of teachers (65.1%) disagrees with the statement that successful IBL requires learners to have extensive Life Sciences content knowledge, as evidenced by a low mean score of 2.33. This suggests that while some teachers may view content knowledge as crucial, there is a broader belief that IBL can be effectively implemented even if learners do not possess extensive prior knowledge. In summary, the findings indicate a generally favorable view of inquiry-based learning among teachers, with a strong interest in its implementation and a desire for further support. Teachers acknowledge the value of IBL in promoting learner inquiry and independent research, though there are concerns about the necessity of extensive prior content knowledge for successful implementation. The average mean score of 3.46, with a standard deviation of 1.100, reflects a positive yet nuanced perspective on IBL, highlighting both the potential benefits and the challenges associated with its adoption in Life Sciences education.

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Table 6
Teachers' Beliefs about the Use of Inquiry-based Learning

Item	Strongly Disagree/ Disagree		Neutral		Strongly Agree/ Agree		*M*	*SD*
	N	%	*N*	%	*N*	%		
I understand the process of inquiry-based learning.	11	25.6	8	18.6	24	55.8	3.53	1.351
I want to implement inquiry-based learning in my Life Sciences classrooms.	4	9.3	8	18.6	31	72.1	3.72	0.934
I want more support in implementing inquiry-based learning in my Life Sciences.	6	14.0	7	16.3	30	69.8	3.91	1.042
Successful inquiry-based learning requires learners to have extensive Life Sciences content knowledge.	28	65.1	7	16.3	8	18.6	2.33	1.267
Inquiry-based learning allows learners to ask important questions and research instead of only relying on textbooks.	4	9.3	7	16.3	32	74.4	3.81	0.906
							3.46	1.100

Teachers' Beliefs regarding Code-switching in Enhancing Inquiry-based Learning

The analysis presented in Table 6 provides insight into teachers' beliefs on the role of code-switching (CS) in enhancing inquiry-based learning (IBL) within the context of Life Sciences education. The data reflect a range of beliefs about the effectiveness of CS as an instructional strategy. Teachers' beliefs about the importance of code-switching in IBL show a generally cautious outlook. For example, only 16.3% of teachers strongly agree that CS plays a vital role in IBL, with a mean score of 2.84 and a standard deviation of 0.843. Similarly, 16.3% believe that CS enhances learners' conceptual understanding of Life Sciences during inquiry-based activities, as indicated by a mean score of 2.88. These low agreement levels suggest that a significant portion of teachers view CS as having a limited impact on the effectiveness of IBL.

Despite the cautious view, there are some positive perspectives on the role of CS. A substantial number of teachers (58.1%) agree that CS makes learners more engaged in IBL, with a mean score of 3.40. Additionally, 48.8% of teachers feel that using CS in IBL helps them engage learners more effectively in the Life Sciences classrooms, reflected in a mean score of 3.44. This indicates that while the overall enthusiasm for CS may be moderate, there is recognition of its potential to increase learner engagement. Teachers also see some value in CS for helping learners make connections between content. With a mean score of 3.44, and 53.5% of teachers agreeing that CS enhances learners' ability to make content connections, CS is perceived as somewhat beneficial in linking theoretical knowledge with practical applications. Similarly, 44.2% of teachers agree that CS enhances IBL in group activities, although this view is more reserved.

Conversely, a significant number of teachers hold negative views about CS. For instance, 69.8% strongly disagree that CS and IBL are effective for learning, with a mean score of 2.26, indicating a strong scepticism about the value of CS in the inquiry-based approach. This scepticism is further reflected in teachers' mixed feelings about CS's impact on questioning during discussions, with a mean score of 3.53, suggesting that while some teachers see its benefits, there is also notable disagreement.

Overall, the mean score of 3.14 with a standard deviation of 1.116 indicates that teachers generally hold a moderately positive yet cautious perspective on the role of code-switching in enhancing inquiry-based learning. This suggests a recognition of potential benefits, balanced by reservations or considerations regarding its implementation and impact on learning outcomes. While there is acknowledgment of the potential benefits of CS in terms of engagement and content connection, there is also significant concern about its overall effectiveness and impact on the learning process. This mixed sentiment underscores the need for further exploration and evidence-based practices to better integrate CS into IBL strategies in Life Sciences education.

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Table 6
Teachers' Beliefs regarding Code-switching in Enhancing Inquiry-based Learning

Item	Strongly Disagree/ Disagree		Neutral		Strongly Agree/ Agree		*M*	*SD*
	N	%	*N*	%	*N*	%		
Code switching plays a vital role in inquiry-based learning of Life Sciences content.	12	27.9	24	55.8	7	16.3	2.84	0.84
Code switching enhances learners' conceptual understanding of Life Sciences when involved in inquiry-based learning.	11	25.6	25	58.1	7	16.3	2.88	0.96
Code switching makes learners engage more in inquiry-based learning in Life Sciences content.	12	27.9	6	14.0	25	58.1	3.40	1.26
Inquiry-based learning through code switching makes me engage learners more in Life Sciences classrooms.	9	20.9	13	30.2	21	48.8	3.44	1.14
Use of code switching in inquiry-based learning enhances learners' ability to make connections of the learning content	12	27.9	8	18.6	23	53.5	3.44	1.28
Use of code switching in group activities enhances inquiry-based learning.	12	27.9	12	27.9	19	44.2	3.35	1.21
The use of code-switching during discussion allows asking of questions important in inquiry-based learning.	9	20.9	11	25.6	23	53.5	3.53	1.24
Code switching and IBL are a waste of time for learning.	30	69.8	7	16.3	6	14.0	2.26	1.00
							3.14	1.12

Correlation between Teachers' Beliefs about using Code-switching and Inquiry-based Learning

Table 7 presents the correlations between various factors of teachers' beliefs about using code-switching (CS) and inquiry-based learning (IBL). The analysis explores how different aspects of these beliefs are interrelated. The table shows two distinct factors of teachers' beliefs about code-switching. Factor one correlates positively with factor two ($r = .342, p = .023$), suggesting a moderate relationship between these two dimensions of code-switching beliefs. This indicates that teachers who hold positive views on one aspect of code-switching are likely to have positive views on the other aspect. Teachers' beliefs about IBL are significantly correlated with both factors of code-switching beliefs. Specifically, factor one of code-switching beliefs shows a strong positive correlation with teachers' beliefs about IBL ($r = .608, p < .001$). This suggests that teachers who are positive about the role of code-switching in general also tend to have positive beliefs about IBL. Similarly, factor two of code-switching beliefs is also positively correlated with IBL beliefs ($r = .590, p < .001$), indicating that a favorable view on the role of code-switching in teaching is associated with a positive outlook on IBL.

When examining teachers' beliefs about code-switching in enhancing IBL, the correlations are particularly telling:

- Factor one of code-switching in enhancing IBL: This factor shows a strong positive correlation with teachers' beliefs about both factors of code-switching ($r = .547, p < .001$ for factor one; $r = .627, p < .001$ for factor two). This indicates that teachers who believe that code-switching enhances IBL are likely to hold positive views about the role of code-switching in general.
- Factor two of code-switching in enhancing IBL: This factor shows a moderate positive correlation with teachers' beliefs about the use of code-switching in general ($r = .316, p = .039$). Additionally, it has a strong positive correlation with teachers' beliefs about IBL ($r = .582, p < .001$). This suggests that while there is a moderate relationship with general code-switching beliefs, there is a stronger link between this factor and teachers' beliefs about IBL, reflecting that those who see value in code-switching for enhancing IBL are likely to be more supportive of IBL practices overall.

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Interestingly, there is a negative correlation between factor two of code-switching in enhancing IBL and one of the factors of code-switching beliefs (r = -.074), though this correlation is not statistically significant. This indicates a potential divergence in how some teachers perceive the role of code-switching in enhancing IBL versus their general beliefs about code-switching. Overall, the correlations highlight a significant interrelationship between teachers' general beliefs about code-switching and their specific beliefs about its role in enhancing IBL. Positive beliefs about code-switching are strongly associated with positive beliefs about IBL, suggesting that teachers who see the benefits of code-switching in general are more likely to support its use in inquiry-based approaches. This underscores the importance of aligning beliefs about code-switching with the pedagogical goals of enhancing inquiry-based learning.

Table 7
Correlation between Teachers' Beliefs about Using Code-switching and Inquiry-based Learning

Correlations		Teachers' belief about the use of code switch - factor one	Teachers' belief about the use of code switch - factor two	Teachers' beliefs about the use of Inquiry-based learning	Teachers' beliefs about the use of code switching in enhancing Inquiry-based learning - factor one	Teachers' beliefs about the use of code switching in enhancing Inquiry-based learning - factor two
Teachers' belief about the use of code switch - factor one.	*r*	1				
	N	44				
Teachers' belief about the use of code switch - factor two.	*r*	.342*	1			
	N	44	44			
Teachers' beliefs about the use of Inquiry-based learning.	*r*	.608**	.590**			
	N	43	43			
Teachers' beliefs about the use of code switching in enhancing Inquiry-based learning - factor one.	*r*	.547**	.627**	1		
	N	43	43	43	1	
Teachers' beliefs about the use of code switching in enhancing Inquiry-based learning - factor two.	*r*	-0.074	.316*	.582**		1
	N	43	43	43	43	43

**. Correlation is significant at the p = .01 level (2-tailed).
*. Correlation is significant at the p = .05 level (2-tailed).

Possible Differences by Applying t-test

Table 8 presents the results of an independent samples t-test conducted to test whether there were differences in male and female teachers' beliefs about the use of code switching in IBL. Levene's Test for Equality of Variances showed no significant differences between the groups, with F-value of .710 (p = .405) for code-switching and F-value of .739 (p = .395) for IBL. This suggests that the assumption of equal variances was tenable for the subsequent t-tests. For factor 1, the t-test for Equality of Means yielded a t(t-value of -.525 with 40 degrees of freedom *(df*), and the two-sided significance level (p) was .301. The mean difference was .602, with a standard error of .204, and the 95% confidence interval for the difference ranged from -.987 to .580, indicating no statistically significant difference in teachers' beliefs about using code-switching. Similarly, for factor 2, the t-value was -.373 with 40 degrees of freedom, and the two-sided p-value was .355. The mean difference was .711, with a standard error of .094, and the 95% confidence interval ranged from -.602 to .414, again indicating no statistically significant difference in teachers' beliefs regarding code-switching.

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Teachers' Beliefs about the use of Code-switching - Factor 1

Equal Variances Assumed: The t-test results show a t-value of -.525 with 40 degrees of freedom (*df*) and a two-sided p-value of .301. The mean difference between the two groups is .602, with a standard error difference of .204. The 95% confidence interval for the mean difference ranges from -.987 to .580. These results suggest that there is no statistically significant difference between the groups regarding their beliefs about factor 1 of code-switching. The confidence interval includes zero, indicating that the observed difference could be due to random variation.

Equal Variances Not Assumed: After adjusting for unequal variances, the t-value is slightly modified to -.534 with 39.965 degrees of freedom and a two-sided p-value of .298. The mean difference remains .596, with a standard error of .204. The 95% confidence interval for this difference spans from -.975 to .567, reinforcing that there is no significant difference between the groups.

Teachers' Beliefs about the use of Code-switching - Factor 2

Equal Variances Assumed: The t-test for factor 2 yields a t-value of -.373 with 40 degrees of freedom and a two-sided p-value of .355. The mean difference is .711 with a standard error difference of .094. The 95% confidence interval for this mean difference is from -.602 to 0.414. These results indicate that there is no statistically significant difference between the groups regarding their beliefs about factor 2 of code-switching. The interval includes zero, supporting the conclusion that the difference is not significant.

Equal Variances Not Assumed: With unequal variances, the t-value is -.371 with 37.310 degrees of freedom and a two-sided p-value of .356. The mean difference is slightly adjusted to .713, with a standard error difference of .094. The confidence interval for this mean difference ranges from -.606 to .419, reinforcing the lack of significant difference between the groups.

Table 8
Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	*p*	*t*	*df*	One-Sided p	Two-Sided p	*MD*	SE_{diff}	Lower	Upper
Teachers' belief about the use of code switch - factor 1	Equal variances assumed	.710	.405	-.525	40	.301	.602	-.204	.388	-.987	.580
	Equal variances not assumed			-.534	39.965	.298	.596	-.204	.381	-.975	.567
Teachers' belief about the use of code switch - factor 2	Equal variances assumed	.739	.395	-.373	40	.355	0.711	-.094	.251	-.602	.414
	Equal variances not assumed			-.371	37.310	.356	.713	-.094	.253	-.606	.419

Overall, the findings suggest that there are no significant differences in teachers' beliefs about the use of code-switching across the two factors analyzed. This indicates a level of consensus among teachers regarding the benefits or effectiveness of code-switching in educational contexts, highlighting the need for further exploration of the nuances within these beliefs to better understand the role of code-switching in enhancing teaching and learning.

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Discussion

The research into teachers' and learners' beliefs about the use of code-switching in Life Sciences classrooms reveals a complex interplay of language dynamics that significantly influences learning outcomes. These findings align with perspectives put forth by Cahyani et al. (2016), who argue that teachers perceive code-switching as an effective pedagogical strategy, especially in multilingual classrooms where the complexity of scientific concepts can pose challenges for learners. This understanding is further supported by Kwamwangamalu (2010) and Junandi (2019), who highlight the role of code-switching in making scientific content more accessible by allowing teachers to utilize languages familiar to their learners.

The findings indicate that teachers utilize code-switching not only to clarify complex concepts but also to provide clear instructions, ensuring learners comprehend the material. As noted by Globler (2018) and Chikiwa and Schafer (2016), this strategy fosters an inclusive learning environment conducive to cognitive development. By facilitating communication and understanding, code-switching emerges as a vital tool for managing the linguistic diversity present in Life Sciences classrooms, which is essential for enhancing learners' engagement and comprehension.

From the learners' perspective, code-switching is perceived as a beneficial strategy that mitigates the cognitive burden of learning scientific concepts in a second language. The findings suggest that learners appreciate the ability to connect new knowledge with their existing understanding in their home language. This connection not only enhances comprehension but also aids in the retention of information, as supported by Corcoll (2013). The learners' ability to bridge new scientific concepts with prior knowledge reinforces the cognitive processing necessary for deep understanding, as corroborated by Mujioono et al. (2013).

While the benefits of code-switching are evident, it is crucial to consider the potential limitations highlighted in the literature. Abdullah and Hussin (2021) note that although code-switching is a valuable pedagogical tool in science classrooms, it must be implemented thoughtfully to avoid hindering long-term language proficiency. Teachers are encouraged to strike a delicate balance between facilitating immediate comprehension and promoting language development, a sentiment echoed by Maluleke (2019).

Teachers' beliefs regarding code-switching extend beyond its functional use, reflecting a deeper understanding of their role as language mediators in diverse classrooms. As Fatimah (2016) suggests, teachers often adapt scientific literacy to cater to the linguistic needs of their learners. This mediation requires advanced pedagogical skills and a strong awareness of language dynamics, as emphasized by previous researchers (e.g. Makgota, 2014; Abdullah & Hussin, 2021). In multilingual settings, code-switching is generally regarded as an effective teaching strategy, whereas its application in monolingual contexts may be viewed differently, potentially as an indication of inadequate language instruction (Ferreira, 2011).

The findings also indicate that teachers advocate for code-switching, particularly when learners are studying science in English as their second or third language, confirming previous findings by Almelhi (2020). Teachers believe that code-switching can empower learners, enhancing their comprehension while fostering active participation. This empowerment is particularly evident when learners express themselves in their home languages, leading to increased confidence, engagement, and facilitative discussions (Al-Qaysi, 2018; Grobler, 2018).

Moreover, learners recognize code-switching as both a social and cognitive tool that fosters peer relationships and aids in bridging knowledge gaps. The practice enables them to clarify ideas, negotiate meanings, and collaboratively enhance group understanding, thereby enriching the classroom experience. The convergence of beliefs among both learners and teachers regarding the benefits of code-switching highlights its role in creating a dynamic and engaging learning environment.

In summary, the pedagogical implications of code-switching are profound. Maluleke (2019) emphasizes that for code-switching to be effective, teachers must strategically employ it to reinforce learning objectives without undermining the language of instruction. This balanced approach not only helps learners establish a strong foundation in the instructional language but also allows them to benefit cognitively from the supportive role of code-switching (Songxaba et al., 2017). By encouraging learners to utilize code-switching as a learning technique rather than merely a communication strategy, teachers can help them navigate linguistic barriers and enhance their overall academic success, as highlighted by Ferreira (2011). Thus, these findings underscore the importance of recognizing and harnessing code-switching as a vital component of pedagogical practice in Life Sciences education.

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Conclusions and Implications

Research into teachers' and learners' beliefs about the use of code-switching in Life Sciences classrooms underscores the intricate role of this pedagogical strategy in navigating language dynamics and improving learning outcomes. This is because it enables teachers to clarify complex concepts, provide clear instructions, and ensure that learners understand the material, thereby fostering an inclusive learning environment that supports the cognitive development of learners. Learners, too, recognize the value of code-switching. They perceive it as a useful strategy that alleviates the cognitive load associated with learning scientific concepts in a second language. By linking new knowledge with their prior understanding in their home language, learners enhance their comprehension and retention of the material. However, its implementation requires careful consideration of its limitations and potential drawbacks. Teachers must strike a balance between immediate comprehension and long-term language proficiency to ensure that code-switching facilitates rather than impedes learning. From the teachers' perspective, code-switching is more than a mere tool for conveying scientific concepts; it is crucial for effectively communicating with linguistically diverse learners. They believe that code-switching can empower learners by enhancing their comprehension and encouraging active participation. On the other hand, learners believe code-switching as both a social and cognitive tool that fosters peer relationships and helps bridge knowledge gaps. They frequently use code-switching to clarify ideas, negotiate meanings, and expand group understanding in collaborative settings. This peer interaction can enhance learning and create a more engaging classroom environment. Both learners and teachers share similar views on the benefits of code-switching. Therefore, code-switching has significant pedagogical implications.

The beliefs held by both teachers and learners about code-switching are pivotal in determining its effectiveness as a pedagogical tool. Positive beliefs can enhance comprehension, foster engagement, and strengthen social interactions within the classroom. Conversely, these beliefs must be balanced with a focus on language proficiency to ensure that code-switching serves as an effective strategy for enhancing teaching and learning outcomes. By acknowledging and harnessing these beliefs, teachers can create a more inclusive and effective learning environment that leverages the benefits of code-switching.

Recommendations

The study reveals nuanced insights into how code-switching is perceived and utilized in educational settings. The recommendations presented aim to address both the practical and theoretical implications of these beliefs, emphasizing the need for thoughtful integration of code-switching strategies in teaching practices and curriculum design. Reflecting on these recommendations offers a deeper understanding of their potential impact and feasibility. The recommendation to enhance teachers' professional development on code-switching highlights a critical need for targeted support. Professional development programs are essential in equipping educators with the knowledge and skills to navigate the complexities of code-switching. Professional development must be tailored to the specific contexts and challenges faced by teachers. Workshops should not only cover theoretical aspects but also provide practical, context-specific strategies that teachers can readily apply in their classrooms. Effective professional development should be ongoing rather than a one-time event. Continuous support and feedback mechanisms are crucial for teachers to refine their practices and stay updated with emerging trends in educational linguistics.

Curriculum developers must be sensitive to the diverse linguistic backgrounds of learners. Curricula that incorporate code-switching can enhance accessibility and engagement, but they must be designed with a deep understanding of local linguistic and cultural contexts. There is a delicate balance between using code-switching to support comprehension and ensuring that it does not undermine the learning of the primary language of instruction. Careful consideration must be given to how code-switching is employed to complement, rather than replace, key educational content. Creating opportunities for learners to express their preferences and experiences with code-switching can lead to more responsive and effective teaching strategies. However, this requires a supportive classroom culture where learners feel comfortable sharing their views. Learners' attitudes towards code-switching can vary widely based on their individual experiences and backgrounds. Recommendations must consider this diversity and aim to create flexible, learner-centered learning environments that accommodate different needs. It is crucial to ensure that feedback mechanisms are genuine and that learner voices are actively incorporated into teaching practices, leading to a more inclusive educational experience.

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Overall, these recommendations reflect a commitment to improving educational practices through a nuanced understanding of code-switching. By addressing the practical implications for teachers, curriculum developers, and learners, and by fostering ongoing research, we can better harness the potential of code-switching to enhance teaching and learning in Life Sciences classrooms.

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Declaration of Interest

The authors declare no competing interest.

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